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Dock t F-3278C **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of: Skeem et al.

Serial No.: 08/892,836 Group No.: 3723

Filed: July 17, 1997 Examiner: G.Nguyen

For: Metal Single Layer Abrasive Cutting Tool Having a Contoured Cutting Surface

Box AF
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

APPEAL BRIEF

Real Party in Interest

The real party in interest is Norton Company, a Massachusetts corporation, having a principal place of business at One New Bond Street, Worcester, MA 01615-0138. Norton Company is the owner of the above-captioned patent application by assignments from the inventors. The assignments are recorded at reel 7981, frame 0063, and reel 8569, frame 0910 of the United States Patent and Trademark Office.

Related Appeals and Interferences

No related interferences known to appellant or to appellant's legal representative or assignee will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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Status of Claims

On February 1, 1999, Appellants appealed from the Final Rejection, mailed January 14, 1999, of claims 1, 3-26 and 28-34. Claims 2 and 27 are withdrawn from consideration as being directed to a non-elected species.

The claims on appeal are set forth in Appendix A annexed hereto. The claims withdrawn from consideration are set forth in Appendix B annexed hereto.

Status of Amendments

All amendments have been entered by the Examiner.

Summary of the Invention

The claimed invention relates to cutting tools comprising a single layer of superabrasive grains chemically bonded onto a monolithic substrate having a plurality of contoured teeth extending from a substrate surface.

The tools of the invention comprise a plurality of cutting levels of abrasive grains parallel to the substrate surface and oriented such that at least a portion of each cutting level of each tooth overlaps each of the other parallel cutting levels of the tooth. As a result of this structure, the bonded grains on the lower parallel cutting levels support the grains in the uppermost cutting level which are in contact with the workpiece during cutting. In addition, each tooth is contoured such that in the uppermost cutting level a ring of the abrasive grain around the contoured surface of each tooth is in contact with the workpiece during cutting. See page 8, lines 17-24, and the Figures.

The teeth on the tools of the invention preferably have a negative rake angle in the direction of motion. In certain embodiments, the teeth of the tools will have a negative rake angle in either a clockwise or a counterclockwise direction of motion (e.g., Fig. 2).

In most prior art tools comprising a single layer of abrasive grain, the grain has been adhered to a substrate by electroplating or by an adhesive or by some other physical bonding mechanism. The strength of a physical bond is significantly less than the strength of a chemical bond-such as the braze used to bond the abrasive grain to the tools of the invention.

To chemically bond diamond or CBN abrasive grain to a metallic substrate surface, the bonding agent is preferably an active braze or other composition comprising an element reactive with the carbon or the nitride on the surface of the grain. For example, preferred brazes contain a nickel-chromium material, or a bronze-titanium material. (See page 19, lines 9-17.) In addition, the grain must be bonded to the substrate at a temperature of about 1000-1100 °C for chromium or about 850-950 °C for titanium under an inert atmosphere to form a chemical bond between the abrasive grain and the metal substrate.

As a result of this structure, the grains bear the majority of the load or cutting forces, the penetration rate of the tool is improved, a freer cut is achieved and the steady state cutting rate equilibrium is extended, with maximum utilization of grain and tool life.

In addition, the structure of the tools of the invention provides the benefit of reduced undercutting. Undercutting is the premature wear of the steel or other substrate surface caused by contact with hard debris generated during cutting concrete, and the like, while the grain retains useful life. The tools of the invention are designed so that the ring of

chemically bonded abrasive grain around each tooth on the lower levels of the plurality of overlapping cutting levels of abrasive grain functions as a surface guard against the undercutting of the metal support structure of the teeth. See page 8, lines 25-27 and page 9 and Figure 2. The only supporting structure exposed to the workpiece or its debris is the cross-sectional area of the tooth within the operative cutting level. This supporting structure is designed to wear as the grain wears to expose the next cutting level. Thus, grain and support wear rates are synchronized. See claims 13 and 30. As the cutting levels wear, the amount of protection remains constant until the lowermost cutting level is in use. See page 14. The design ensures full grain life, improved tool life and protection from loss of teeth due to undercutting during tool usage.

Issue

Whether claims 1, 3-26 and 28-34 are patentable under 35 USC Section 103(a) over U.S. Pat. No. 5,018,276 to Asada ("Asada"), in view of U.S. Pat. No. 5,215,072 to Scott ("Scott "), and U.S. Pat. No. 3,894,673 to Lowder, et al. ("Lowder").

Grouping of Claims

Appellants consider each claim herein to be separately patentable.

Claim 1 is one of four independent claims. Claim 1 is directed to an abrasive cutting tool comprising a monolithic substrate having a plurality of contoured teeth extending from the substrate; a chemically bonded single layer of superabrasive grains on the teeth, the grains defining a plurality of overlapping cutting levels on each tooth; and a first uppermost cutting level of grains and successive cutting levels on each tooth. During cutting the uppermost cutting level tool is worn away first, and, then, each successive uppermost cutting level presents to the workpiece a ring of grains

around the contoured surface of each tooth, such that substantially all grains within the ring simultaneously engage in cutting. Claims 2-12 and 33 depend from claim 1.

Claims 3-4, 10, 14-16, 28-29 and 34 specify a preferred tooth design having a negative rake angle. These claims describe tool embodiments illustrated in Figures 3, 6, 7, 10 and 11.

Claims 3, 4 and 6, and claims 16, 17 and 18 specify preferred grain placement and concentration on the surfaces of the teeth. In one embodiment (claims 3 and 16), the angle of inclination of the negative rake is no more than one-third of the percent concentration of grains bonded to the negative rake portion of the tooth (Figures 3, 6, 10 and 11). In another embodiment (claims 4, 6, 17 and 18), at least 50% of the successive cutting levels contain about the same number of grains (Figures 3, 7, 10 and 11).

Claims 7 and 19 specify preferred tooth designs of claims 6 and 18, respectively, wherein successive cutting levels having the same number of grains also have a constant cross sectional area. Claims 8 and 20 specify preferred tooth designs of claims 6 and 18, respectively, wherein upper successive cutting levels of each tooth have a smaller cross sectional area than lower cutting levels of each tooth (Figure 6). Claim 9 and 23 specify a preferred embodiment of claim 6 and 18, respectively, wherein the successive cutting levels having the same number of grains comprises the lower 50% of the cutting levels of each tooth (Figures 3, 7, 10 and 11).

Claim 10 specifies the tool of claim 1 having a preferred trapezoidal tooth cutting surface. Claim 11 specifies the tool of claim 1 having a preferred abrasive grain content of less than 75% grain concentration. Claim 12 specifies the tool of claim 1 having a preferred tooth hardness of 38 to 42 Ra.

Claim 13, the second independent claim, is directed to a method of cutting with the tools of the invention wherein a constant force is achieved at the point of contact with the workpiece; effective cutting is achieved; and the rates of wear resistance of the teeth and fracture of the grain are approximately equal on the first uppermost cutting level. Claims 14-26 depend from claim 13.

Claim 21 specifies the method of claim 13 using a grain having a preferred grain strength index of at least one minute according to the FEPA standard for diamonds. Claim 22 specifies the method of claim 13 using a grain having a preferred abrasive grain size of about 100 to 600 microns. Claim 24 specifies the method of claim 13 using a preferred grain concentration of less than 75%. Claim 25 specifies the method of claim 13, wherein the workpiece is masonry having a Knoop hardness of at least 700 Rc. Claim 26 specifies the method of claim 13 using teeth having a hardness of 38 to 42 Ra.

Claim 28, the third independent claim, is directed to a group of tools basically as described in claim 1, but also having teeth with a negative rake angle. Claims 29 and 34 depend from claim 28. Claim 29 specifies a preferred design of claim 28 tools, wherein the uppermost 10% of each tooth comprises a face inclined at a negative rake angle with respect to the direction of movement.

Claim 30, the fourth independent claim, is directed to a tool having the basic geometry of the tools of claim 1 and exhibiting approximately equal rates of wear resistance in the substrate and teeth to fracture resistance in the abrasive grain at a given cutting level on the teeth. Claim 31 depends from claim 30.

Claim 31 specifies the tool of claim 30 using a grain having a preferred grain strength index of at least one minute according to the FEPA standard for diamonds. Claim 32 specifies the tool of claim 30 using teeth having a hardness of 38 to 42 Ra.

Claims 33 and 34 depend from claims 1 and 28, respectively, and specify a preferred class of tools (e.g., saw blades) having the structural attributes of the invention.

Thus, there are four independent sets of claims, with a variety of preferred embodiments recited in 30 dependent claims, and these claims do not stand or fall together.

Argument

Appellants' claims 1, 3-26 and 28-34 are patentable under 35 USC Section 103 over the Asada reference, in view of Scott and Lowder.

Appellants' claims require a chemical bond between the abrasive grain and the substrate, in combination with all other structural and functional elements recited in the claims. The tools defined in independent claims 1, 28 and 30 are much more than just tools having a single layer of abrasive grain precisely placed on the teeth of a monolithic disc, or just tools made with chemically bonded abrasive grain, or just tools having negative rake angle cutting teeth. The presence of teeth having a first layer, and successive ring shaped layers, of chemically bonded single layer diamond grains is critical to the claimed tool performance and this structure is neither disclosed nor suggested in the cited references.

The Asada Reference

The Asada reference, cited by the Examiner as the primary reference, discloses electroplated cutting tools in the form of saw blades having a monolithic substrate with cutting teeth and abrasive grain bonded to the teeth with electroplated metal.

The obvious functional shortcomings of electroplated single layer abrasive grain tools relative to chemically bonded abrasive cutting tools and negative rake angle tools are demonstrated in the laboratory tests described in the Second Declaration of inventor Buljan. A copy of his declaration is annexed hereto as Appendix C.

Asada teaches away from a tooth design having "an initial cutting level" as set forth in Appellants' claims. Asada teaches the uppermost layer of diamond on the perimeter of the teeth should be removed prior to use of the tool (see, e.g., col. 2, lines 10-22, of Asada). Additionally, it is not clear that Asada achieves a single layer of diamond abrasive grain on the teeth, as electroplating tends to unevenly deposit areas having multiple layers of grain on the substrate surface, along with areas having single layers of grain. Teeth having a negative rake angle with respect to the direction of cut are neither suggested nor disclosed.

The secondary references, in combination, fail to supply all of the structural elements of the invention that are missing from the Asada disclosure. Due to these significant structural dissimilarities between the cited reference and the invention, the rejection fails to state a prima facie case of obviousness. See, In re Grabiak, 226 USPQ 870 (Fed. Cir., 1985).

The Scott Reference

The Scott reference, cited by the Examiner as a reference suggesting the desirability of modifying Asada to arrive at Appellant's invention, discloses a chain-saw. The chain-saw comprises cutting inserts made of abrasive grain bonded in the openings of a wire mesh carrier mounted on rubber pads and glued to links of the chain. The Scott cutting inserts are mounted on the chain of a chain saw and are operated at a negative rake angle relative to the direction of cut.

The cutting inserts are described in two prior art patents, U.S. Pat. Nos. 4,925,457 and 5,049,165 (cited in column 4, lines 50-68, together with the text in column 5, lines 15-

17, of Scott). As may be determined by reviewing these patents, the abrasive grain used in the cutting elements of the Scott chain saw is not chemically bonded to the mesh substrate.

The Scott tool does not comprise a monolithic substrate, or a substrate surface, or a plurality of teeth extending therefrom. Furthermore, although the mesh cutting element (or insert) is inclined in a negative rake angle relative to direction of cut, it can be seen from Figures 4, 5, 6, and 7 of Scott that the tool does not comprise a plurality of cutting levels parallel to the substrate surface and oriented such that at least a portion of each cutting level of each tooth overlaps each of the other parallel cutting levels of the tooth. Scott teaches only a row of physically bonded grain oriented perpendicular to the direction of motion, across the width of the top surface and along an upper part of the side surfaces of the cutting link where it contacts the workpiece during cutting. The tool does not provide cutting levels having a ring of grain around the contoured surface of each tooth and in contact with the workpiece so that substantially all superabrasive grain within the ring simultaneously engages in cutting.

Each row of abrasive grains in each mesh cutting element of Scott is not supported by monolithic metal, does not overlap the next row of grain, and is not supported-at least partially- by an additional row of abrasive grains. Scott's successive rows of grains (in contrast to the successive rings of grain as recited in Appellant's claim 28) provide no undercut protection and no side relief for free rotation of the tool. Relative to a ring of grain, the row of grain yields larger chip thickness and a less uniform cut into the workpiece. Even in the circular saw design (suggested at col. 8, lines 16-18 of Scott), the Scott cutting

elements would display an increase in power draw, less free cut and decreased tool life relative to the tools of the invention.

According to the Scott teachings, components of the chain link, in addition to the abrasive grain but present at the same height as the "cutting level" of abrasive grain, must be in contact with the workpiece during cutting. The Scott design will increase the area of contact of tool components with the workpiece, thereby decreasing cutting efficiency. Without the benefit of a ring of chemically bonded grain around the link to protect the moving parts of the links and the mesh substrate that supports the grain from contact with the workpiece and debris, the support means are likely to wear before the abrasive grain life is exhausted.

Scott's cutting elements are completely vulnerable to erosion and premature detachment of abrasive grain and/or the mesh on which the grain is carried. Nothing in the construction or design of the Scott cutting elements will prevent cutting debris from entering underneath the mesh elements and damaging the mesh or its attachment points or the pivot mechanisms or the metallic attachment of the links to the remainder of the chain. Thus, while Scott's chains may be initially free-cutting, they do not have the necessary elements to insure long operational life and will likely experience wear failure before the expensive diamond abrasive grain has been consumed.

Evidence of these deficiencies is presented in the Buljan declaration (Appendix C). The limited role of negative rake design in the benefits achieved by Appellants' tools is established by the data presented in the Buljan declaration. It can be seen that a single row of diamond grain bonded to the leading edge of negative rake teeth by a chemically

reactive braze lacks the tool life and other benefits achieved with a ring of diamond grain on an equivalent tool under identical test conditions.

In the work described in the Buljan declaration, the negative rake performance was measured with a chemically reactive braze on a monolithic substrate, rather than on the non-reactive bond and mesh and non-monolithic substrate Scott teaches. Thus, the Scott tool model system Buljan tested was made with an improved design relative to the one actually disclosed by Scott, yet it still did not perform as well as the claimed tools.

Furthermore, the negative rake design is an optional element of Appellants' invention, recited only in claims 3-4, 10, 14-16, 28-29 and 34. Claims 1, 5-9, 11-13, 17-26 and 33 do not incorporate a negative rake angle as an essential element of the tool needed to yield a freer cut, longer tool life and maximum use of diamond grain. Thus, Scott's disclosure of a negative rake angle in the cutting elements of the tool chain is not relevant to claim 1 and claims 5-9, 11-13, 17-26 and 30-33.

With respect to claims 13 and 30, the Scott design fails to provide steady state cutting conditions of the sort described in Appellants' text on page 11, lines 17-25, and Fig. 2. The Scott design cannot provide steady state cutting conditions (consistent penetration rate and power consumption) because Scott does not have a "ring" of abrasive grain around the mesh cutting element. Therefore, during cutting, as the tool is worn and as the area of contact between the cutting element and the workpiece increases, there is no increase in the number of diamond grains in contact with the workpiece. In contrast, Appellants' tool design increases the number of grains in contact with the workpiece as the

tool wears and the area of contact between the tooth and the workpiece increases to produce steady-state conditions. (See Figure 5.)

For these reasons, Scott's design cannot yield the combined benefits of high cutting rate, high penetration rate, long steady state cutting conditions, and long tool life observed with the chemically bonded grain and monolithic core and tooth geometry designs specified for the tools of Appellants' invention.

Further, Appellants' tools may be operated in either rotational direction without loss of performance. This is not true of the cutting chains of Scott which are very likely to come unraveled if operated in a positive rake direction. Lastly, by emphasizing the benefits and the criticality of a negative rake design, Scott's disclosures actually teach away from the notion that a variety of tooth angles and geometries, as defined in Appellants' claim 1, share such benefits.

The Lowder Reference

Lowder was cited as evidence of knowledge in the art of the benefits of a chemically active bond in single layer abrasive grain tools. Lowder is silent regarding tool geometry, steady state cutting rates, freedom of cut and other structural limitations and functional attributes of Appellants' claimed invention. It contains no suggestion to use negative rake angle teeth coated with abrasive grain or to otherwise combine the various structural limitations of Appellants' invention with a chemically reactive bond.

Obviousness Analysis

If, as the Examiner has indicated, In re Keller, 208 USPQ 871 (CCPA 1981), is the appropriate Section 103(a) law to apply in Appellants' case, then the issues are :

1) What would Asada, in view of Lowder, suggest to one skilled in the art ?

2) What would Scott, in view of Lowder, suggest to one skilled in the art ?

(See Keller, at page 882.)

Asada, in view of Lowder, might suggest that tool life could be extended by substituting diamond attached with a braze having a chemically reactive component for the electroplated diamond of Asada. However, Lowder (1975) was available to Asada (1989) and Asada ignored the possibility of using a reactive braze, or even a braze, and instead teaches the grain should be electroplated to the core of the tool. One skilled in the art may assume Asada rejected Lowder's teachings for some unstated and, therefore, unknown reason. Asada, in view of Lowder, would not suggest the benefits of including a first cutting level of abrasive grain on the teeth of the Asada tool and would not suggest the benefits of controlling the location and concentration of abrasive grain on the teeth.

Scott, in view of Lowder, might suggest that a chemically reactive component be added to braze used to attach the diamond to the mesh. Because Scott fails to teach electroplated monolithic tools, and instead teaches tools comprising an assembly of abrasive-bearing mesh elements, the combination of Scott and Lowder does not lead one skilled in the art to the invention. The combination cannot suggest that the Scott mesh elements will perform in the manner of an electroplated monolithic tool and exhibit improved tool life when a reactive braze is substituted for the bond Scott uses between the mesh and

the diamond. Further, as the abrasive-bearing mesh is neither brazed nor electroplated to the body of the Scott saw, but attached by a bonding agent "e.g., an industrial acrylic adhesive or the like...." (see col. 5, lines 8-10, of Scott), the teachings of Lowder do not apply to modify the Scott teachings.

Furthermore, Appellants' invention includes other benefits, such as free cutting operation ("high penetration rate") and steady state cutting operation over much of the tool life. See page 2, last two lines and page 3, first 2 lines, and Figure 2 of Appellants' specification. Neither Asada in view of Lowder, nor Asada in view of Lowder and Scott suggests these benefits. As demonstrated in the Buljan declaration, the electroplated tool of Asada and the Scott-type tool (even if made with a Lowder modification!) require more time to make a single cut than the tool of the invention and, therefore, lack the free cutting character of the tools of the invention. This benefit of the invention was observed irrespective of whether the teeth of the tool of the invention were made with a negative rake angle (claims 3-4, 10, 14-16, 28-29 and 34) or without a negative rake angle (claims 1, 5-9, 11-13, 17-26 and 33).

Neither the combinations of two of the references, nor a combination of all three references would suggest any of the tooth structures of Appellants' tools to one skilled in the art. On the basis of this Keller analysis, Appellants find a case for obviousness lacking.

Applying the standard for obviousness set forth in MPEP 706.02(j), the legal analysis shifts in a direction even more favorable to Appellants' position. The MPEP test appears to closely follow the decision of In re O'Farrell 7 USPQ2d 1673 (CAFC 1988), and it differs significantly from the Keller analysis. The MPEP states a *prima facie* obviousness

rejection requires the presence of three elements in the prior art. First, there must be a suggestion or motive in the references or in the general knowledge in the art to modify the references or to combine the references. Second, there must be a reasonable expectation of success in making such a combination or modification. Third, the art must teach or suggest all claim limitations.

Here, the Examiner's rejection lacks portions of the first and second elements, as set forth above in the Keller discussion, and fails to heed that the art does not teach or suggest all claim limitations. In particular, the "first uppermost cutting level of grain" on the teeth of a "monolithic" core is completely missing from the references.

To some extent, the steady state, freely cutting character of the tool of the invention is due to the presence of "a first uppermost cutting level" of grain. This first layer is forbidden by the Asada patent and criticized as an undesirable aspect of the prior art (see Figures 7-12, and col. 2, lines 10-22, of Asada). This teaching, even combined with Lowder and Scott, cannot suggest to one skilled in the art any reasonable expectation of success with Appellants' claimed tool design.

Other structural aspects of the tools of the invention are likewise absent from the combined cited references. The tooth geometry and/or the tool type shown in Appellants' Figures 6-9 and 11-12 are not disclosed or suggested. In particular, the references fail to mention core drills: a tool type likely to benefit from high penetration rate and steady state cutting operations, as well as from enhanced tool life.

Appellants' combination "causes a new and useful result" not suggested by Lowder, Scott or Asada individually, nor by the combination of these references. It

is a patentable combination. See, Custom Accessories, Inc. v. Jeffrey-Allan Industries, Inc., 1 USPQ 2d 1196, 1198 (Fed. Cir., 1986). It is only with the hindsight gleaned from Appellants' invention that the obviousness rejection has been made over the cited art. This is not a permissible rejection. Uniroyal v. Rudkin-Wiley, 5 USPQ 2d 1434 (Fed. Cir., 1988).

CONCLUSION

In view of the remarks set forth herein, and the remarks of record, Appellants respectfully request a reversal of the rejection and a remand for an allowance of all claims pending in the application.

Respectfully submitted,

Mary E. Porter

Mary E. Porter
Attorney for Appellants
Registration No. 33,440
Phone No. 508-795-2555

May 12, 1999

Norton Company
1 New Bond Street
Box Number 15138
Worcester, MA 01615-0138
#27982

APPENDIX A

Docket
F-3278

Claims on Appeal
Ser. No.: 08/892,836
Filed: 7/15/97
Skeem, et al

1. (Twice amended) An abrasive cutting tool comprising:

a) a monolithic substrate having a substrate surface with a plurality of teeth extending therefrom, each tooth having a contoured surface,

b) a layer comprising superabasive grains, the layer being chemically bonded to at least a portion of the surface of each tooth to define a plurality of cutting levels parallel to the substrate surface, and each cutting level on each tooth being oriented such that a portion of each cutting level overlaps at least a portion of each other cutting level of the tooth; and

c) a first uppermost cutting level comprising superabrasive grains and successive uppermost cutting levels among the plurality of cutting levels of each tooth; whereby after the first uppermost cutting level has been worn away by cutting a workpiece, each successive uppermost cutting level of the tooth presents to the workpiece a ring of superabrasive grain around the contoured surface of the tooth, and substantially all superabrasive grain within the ring simultaneously engages in cutting.

3. The tool of claim 1 wherein the substrate surface has an intended direction of movement, wherein at least a portion of each tooth has a face which is inclined at a negative angle with respect to the intended direction of movement, and at least a portion of the grains are bonded to the face having the negative angle of inclination.

4. The tool of claim 3 wherein the grains bonded to the face having the negative angle of inclination are present in a concentration wherein the angle of inclination in degrees is no more than 1/3 of the grain concentration in percent.

5. The tool of claim 1 comprising successive cutting levels comprising at least 50% of the plurality of cutting levels, wherein each cutting level of the successive cutting levels contains about the same number of grains.

6. The tool of claim 1 wherein a portion of each tooth is associated with successive cutting levels comprising at least 50% of the cutting levels of the tooth, and wherein each cutting level of the successive cutting levels contains about the same number of grains.

7. The tool of claim 6 wherein the portion of each tooth associated with the successive cutting levels having about the same number of grains has a constant cross section.

8. The tool of claim 6 wherein the portion of each tooth associated with the successive cutting levels having about the same number of grains has an uppermost cross section and a lowermost cross section, and the uppermost cross section is smaller than the lowermost cross section.

9. The tool of claim 6 wherein the successive cutting levels having about the same number of grains comprise at least the lowermost 50% of the cutting levels of each tooth.

10. The tool of claim 9 wherein the substrate surface has an intended direction of movement, wherein at least the uppermost 10% of each tooth has a face which is inclined at a negative angle with respect to the intended direction of movement, and at least a portion of the grains are bonded to the face having the negative angle of inclination, thereby producing a trapezoidal cutting surface.

11. The tool of claim 1 wherein the concentration of the grain is less than 75%.

12. The tool of claim 1 wherein the teeth have a hardness of between about 38 and 42 Ra.

13. A method of cutting, comprising the steps of:

a) providing an abrasive cutting tool comprising:

i) a substrate surface having a plurality of teeth extending therefrom, each tooth having a surface, and

ii) a layer comprising abrasive grains, the layer being chemically bonded to at least a portion of the surface of each tooth to define a plurality of cutting levels parallel to the substrate surface, the cutting levels comprising a first uppermost cutting level and a second uppermost cutting level, the grains having a predetermined wear resistance,

b) moving the substrate surface in an intended direction of rotation,

c) contacting the uppermost cutting level of at least one tooth to a workpiece at a point of contact,

d) applying a constant force to the tool directed at the point of contact,

wherein the constant force is sufficient to cut the workpiece, the strength of the bond is sufficient to resist peeling, the predetermined wear resistance of the grains is such that the grains of the first uppermost cutting level fracture under application of the constant force, and the wear resistance of the teeth are such that the portion of the tooth associated with the first uppermost cutting level wears at about the same rate as the grains of the first uppermost cutting level fracture,

thereby causing essentially simultaneous removal of the grains of the first uppermost cutting level from their bond and the portion of the tooth associated with the first uppermost cutting level, and

thereby exposing the grains of the second uppermost cutting level to the workpiece.

14. The method of claim 13 wherein the plurality of teeth includes successive teeth having successively lower uppermost cutting levels in the intended direction of

movement, thereby producing a cutting surface having a negative angle of inclination with respect to the intended direction of movement.

15. The method of claim 13 wherein at least a portion of each tooth has a face which is inclined at a negative angle with respect to the intended direction of movement, and at least a portion of the grains are bonded to the face having the negative angle of inclination.

16. The method of claim 15 wherein workpiece produces abrasive swarf when cut, and wherein the grains bonded to the face having the negative angle of inclination are present in a concentration wherein the angle of inclination in degrees is no more than 1/3 of the grain concentration in percent, thereby protecting the grains of the uppermost cutting level from undercutting.

17. The method of claim 13 comprising successive cutting levels comprising at least 50% of the plurality of cutting levels, wherein each cutting level of the successive cutting levels contains about the same number of grains.

18. The method of claim 17 wherein a portion of each tooth is associated with successive cutting levels comprising at least 50% of the cutting levels of the tooth, and wherein each cutting level of the successive cutting levels contains about the same number of grains.

19. The method of claim 18 wherein the portion of each tooth associated with the successive cutting levels having about the same number of grains has a constant cross section.

20. The method of claim 18 wherein the portion of each tooth associated with the successive cutting levels having about the same number of grains has an uppermost

cross section and a lowermost cross section, and the uppermost cross section is smaller than the lowermost cross section.

21. The method of claim 13 wherein the grain toughness is characterized by a relative strength index of at least one minute, as measured by the FEPA standard for measuring the relative strength of saw diamonds.

22. The method of claim 13 wherein the grain size is between about 100 um and 600 um.

23. The method of claim 18 wherein the successive cutting levels having about the same number of grains comprise at least the lowermost 50% of the cutting levels of each tooth.

24. The method of claim 13 wherein the concentration of the grain is less than 75%.

25. The method of claim 13 wherein the workpiece is masonry having a Knoop hardness of at least 700 Rc.

26. The method of claim 13 wherein the teeth have a hardness of between 38 Ra and 42 Ra.

28. (Twice amended) An abrasive cutting tool comprising:

a) a monolithic substrate having a substrate surface with a plurality of teeth extending therefrom, each tooth having a contoured surface,

b) a layer comprising abrasive grains, the layer being chemically bonded to at least a portion of the surface of each tooth to define a plurality of cutting levels parallel to the substrate surface, and each cutting level on each tooth being oriented such that a portion of each cutting level overlaps at least a portion of each other cutting level of the tooth; and

c) a first uppermost cutting level and successive uppermost cutting levels comprising superabrasive grains among the plurality of cutting levels of each tooth; wherein the substrate surface has an intended direction of movement, wherein at least a portion of each tooth has a face which is inclined at a negative angle with respect to the intended direction of movement, and at least a portion of the abrasive grains are bonded to the face having the negative angle of inclination, and whereby after the first uppermost cutting level has been worn away by cutting a workpiece, each successive uppermost cutting level of the tooth presents to the workpiece a ring of superabrasive grain around the contoured surface of the tooth, and substantially all superabrasive grain within the ring simultaneously engages in cutting.

29. The tool of claim 28 wherein at least the uppermost 10% of each tooth comprises the face which is inclined at a negative angle with respect to the intended direction of movement.

30. An abrasive cutting tool comprising:

a) a substrate surface having a plurality of teeth extending therefrom, the teeth having a surface and a predetermined wear resistance, and

b) a layer comprising abrasive grains, the layer being chemically bonded to at least a portion of the surface of each tooth to define a plurality of cutting levels parallel to the substrate surface, the grains having a predetermined wear resistance, wherein the wear resistance of the teeth and the wear resistance of the grains are predetermined such that, when a given cutting level contacts a workpiece under an optimum load, the grains of the given cutting level wear and fracture at about the same rate as the portion of the tooth associated with the given cutting level wears away.

31. The tool of claim 30 wherein the teeth have a hardness of between 38 Ra and 42 Ra.

32. The tool of claim 31 wherein the grains have a relative strength index of at least one minute, as measured by the FEPA standard for determining the relative strength of saw diamonds.

33. The abrasive cutting tool of claim 1, wherein the tool is selected from the group consisting of saw blades, core drills and abrasive wheels.

34. The abrasive cutting tool of claim 28, wherein the tool is selected from the group consisting of saw blades, core drills and abrasive wheels.

APPENDIX B

Docket
F-3278C

Claims Withdrawn from Consideration
Directed to a Non-elected Species
Ser. No.: 08/892,836
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Skeem, et al

2. The tool of claim 1, wherein the substrate surface has an intended direction of movement and wherein the plurality of teeth includes successive teeth having successively lower uppermost cutting levels in the direction of the intended direction of movement, thereby producing a cutting surface having a negative angle of inclination with respect to the intended direction of movement.

27. An abrasive cutting tool comprising:

a) a substrate surface having a plurality of teeth extending therefrom, each tooth having a surface and

b) a layer comprising abrasive grains, the layer being chemically bonded to at least a portion of the surface of each tooth to define a plurality of cutting levels parallel to the substrate surface,

wherein the substrate surface has an intended direction of movement, wherein the plurality of teeth includes successive teeth having successively lower uppermost cutting levels in the direction of the intended direction of movement, thereby producing a cutting surface having a negative angle of inclination with respect to the intended direction of movement.

APPENDIX C

OIPE JC74 MAY 17 1999 PATENT & TRADEMARK OFFICE

Docket Number F-3278C

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Skeem, et al

Serial Number: 08/892,836 Examiner: G.Nguyen

Filed: 7/15/97 Group Art Unit: 3723

For: Metal Single Layer Abrasive Having a Contoured Cutting Surface

The Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

SECOND DECLARATION UNDER 37 CFR Section 1.132 of Inventor Sergej-Tomislav Buljan

1. I am a named inventor of the above-captioned patent application and I make this declaration in support of the patentability of the application over cited references U.S. Pat. No. 5,018,276 to Asada ("Asada"), U.S. Pat. N. 5,492,771 to Lowder, et al, ("Lowder") and U.S. Pat. No. 5,215,072 to Scott ("Scott").

2. I have a PhD in Solid State Science from The Pennsylvania State University, and over 30 years of experience in research and development working with a variety of materials. I presently hold the position of Manager, Superabrasives Research and Development, at Norton Company where I have worked in research and development relating to superabrasives and metal bonded cutting and grinding tool technologies for over 5 years.

3. Attached to my declaration as Appendix A are drawings of 4 diamond saw blades: 280, 277, 278 and E-plated. These 4 blades represent the following designs:

280: blade of the invention without negative rake (0° rake angle)

277: blade of the invention with negative rake

278: blade with negative rake having abrasive grain in successive rows rather than in successive rings around the teeth (representative of Scott cutting elements having rows, rather than rings of grains at a negative rake)

E-plated blade representing Asada design of equilateral teeth geometry and electroplated grain

4. All blades were made to 230 mm in diameter with 35/40 mesh, grade SDA 100+ mesh diamond grain bonded to a stainless steel cores of the same thicknesses and type. Nickel was used to electroplate grain for the E-plated sample. A chemically reactive braze containing a Cu-Sn-Ti alloy was used to bond the abrasive grain to the core in samples 280, 278 and 277.

5. Blades were mounted on a Bosch GWS 24-230 JC-2400W-6500RPM-max. electric saw for testing. An operator used this saw to make the following test cuts for each blade:

LEVEL 1. Soft Cement Brick.- 50 Cuts, 7 cm deep, 24cm long.

LEVEL 2. Abrasive Concrete Slabs.- 50 Cuts, 4 cm deep, 30 cm long.

LEVEL 3. Hard Concrete Slabs (Washed Concrete).- 30 Cuts, 2 cm deep, 25 cm long.

LEVEL 4. Hard Concrete Slabs (Washed Concrete).- 30 Cuts, 5 cm deep, 25 cm long.

6. Observations of cutting time for one pass and wear of the saw were made for the blades during the 4 levels of cutting tests. Measurements recorded included: (1) Speed of Cutting (Time required to complete 1 cut) and (2) Wear (Reduction in the blade radius). Experimental observations are summarized in the Table below.

Table 1 Cutting Test Results

	Sample 280	**Sample E-Plated**	**Sample 278**	**Sample 277**
Level 1				
Cutting time (s) ,1 pass.	3.00s	3.70s	4.16s	3.00s
Wear (mm)	0.0277 mm	0.0877 mm	0.2488 mm	0.0400 mm
Level 2				
Cutting time (s) ,1 pass.	8.00s	Stopped Cutting	8.00s	7.33s
Wear (mm)	0.0166 mm	Before 30 cuts.	1.5366 mm	0.0188 mm
Level 3				
Cutting time (s) ,1 pass.	12.42 s		Stopped Cutting	6.28s
Wear (mm)	0.0220 mm		after 23 cuts	0.0190 mm
Level 4				
Cutting time (s) ,1 pass.	Stopped Cutting			Stopped Cutting
Wear (mm)	after 3 cuts			after 9 cuts

7. These cutting test results demonstrate the following:

a) Electroplated blades of Asada are substantially inferior to chemically bonded blades of the invention in blade life.

b) Blades representative of Scott's design having rows of abrasive grain at a negative rake (278) are substantially inferior in blade life to blades of the invention having rings of abrasive grain either with (277) or without (280) a negative rake.

c) A negative rake angle is merely a preferred, and not an essential, embodiment for achieving the wear resistance and significantly prolonged tool life attributes of the tools of the invention.

8. Relative to the tools of the invention, the Scott tools are expected to yield a performance even more inferior than shown in these cutting tests because the Scott tools do not contain diamond abrasive chemically bonded to the mesh of the substrate.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Sergej-Tomislav Buljan, PhD   Date: 11/25/98

Norton Company
1 New Bond Street
Box Number 15138
Worcester, Massachusetts 01615-0138

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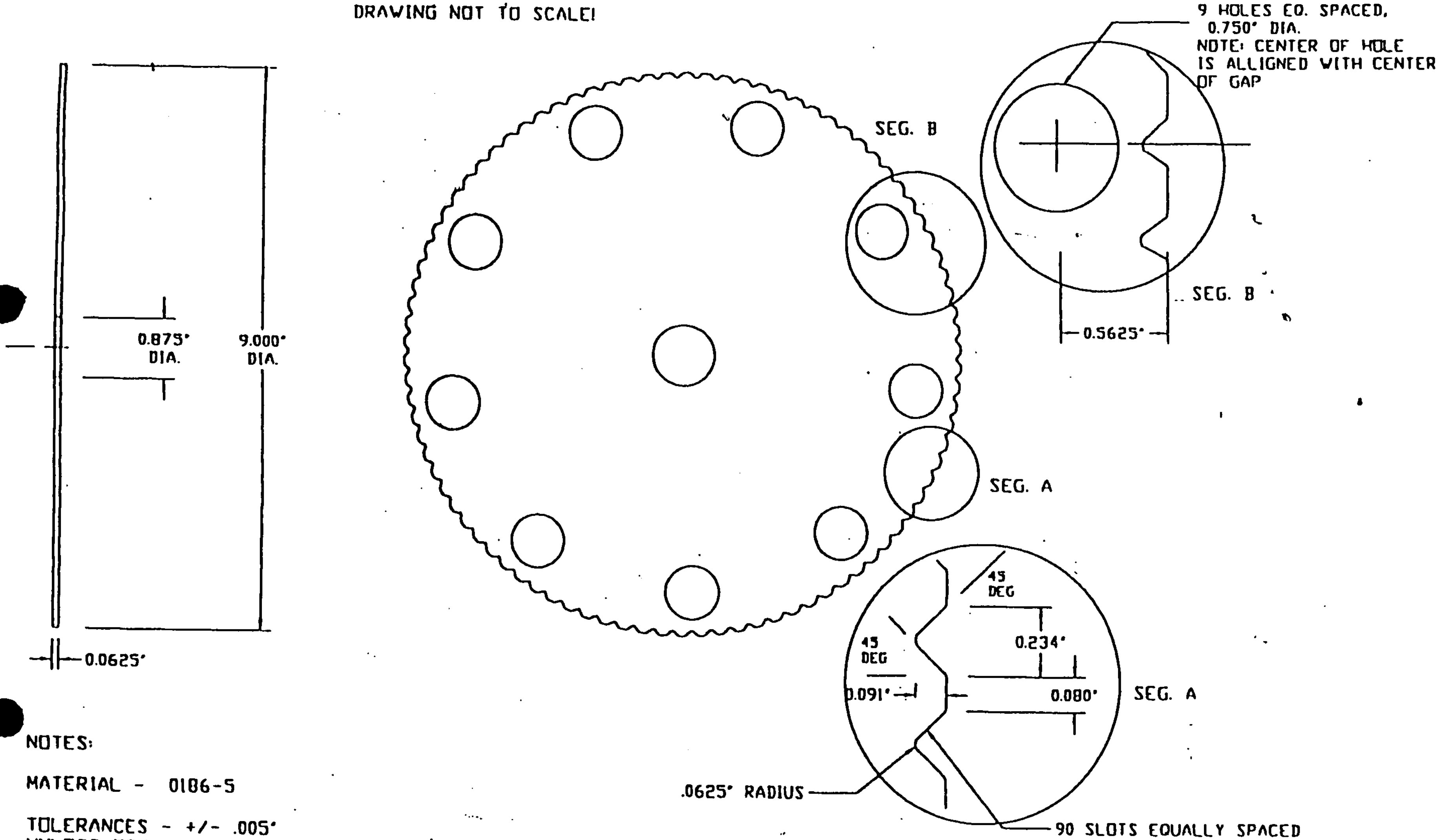
APPENDIX A

DRAWING NOT TO SCALE!



NOTES:

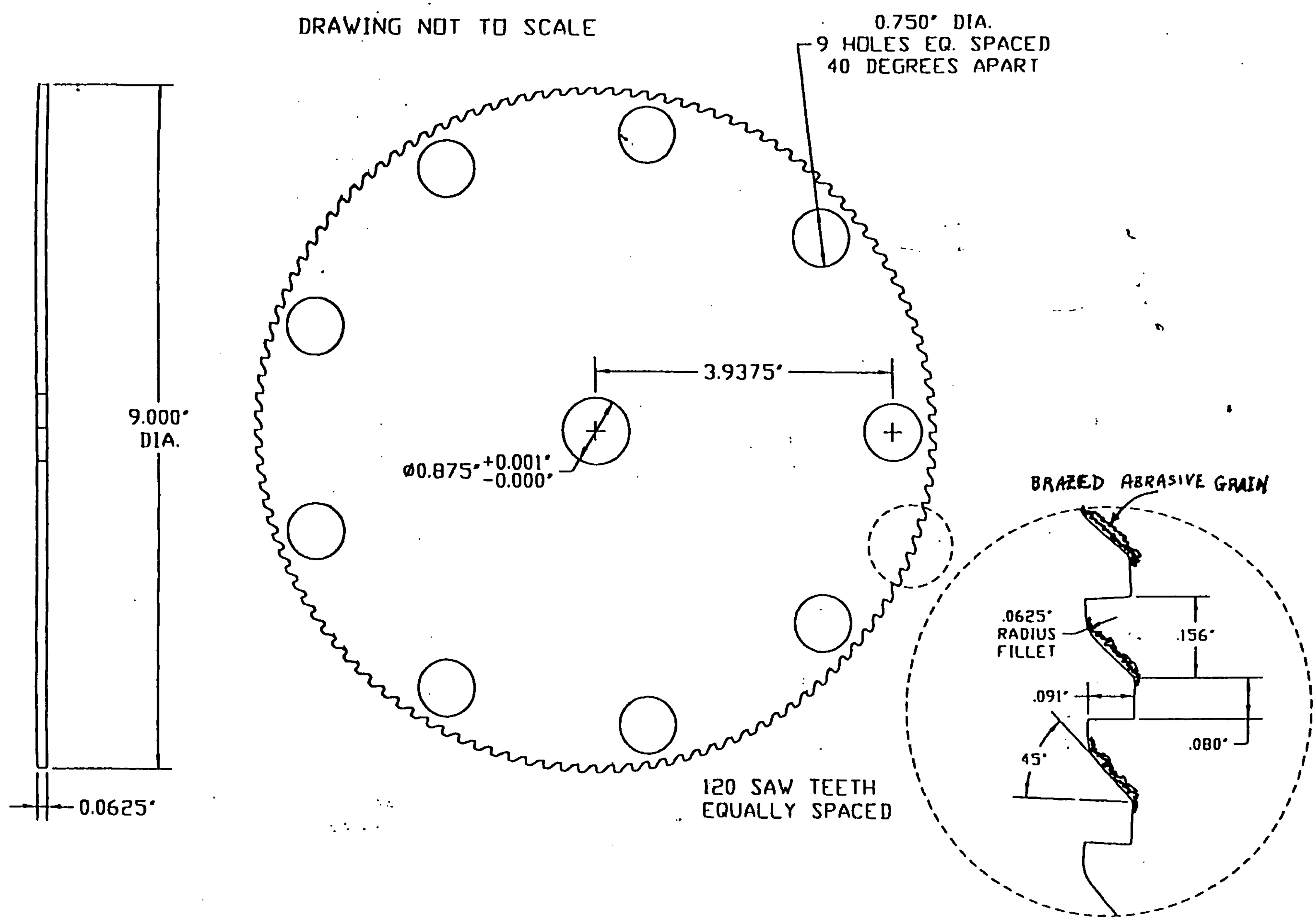
MATERIAL - 0186-5

TOLERANCES - +/- .005"
UNLESS OTHERWISE NOTED

NORTON COMPANY

CONFIDENTIAL

DWG.# 280

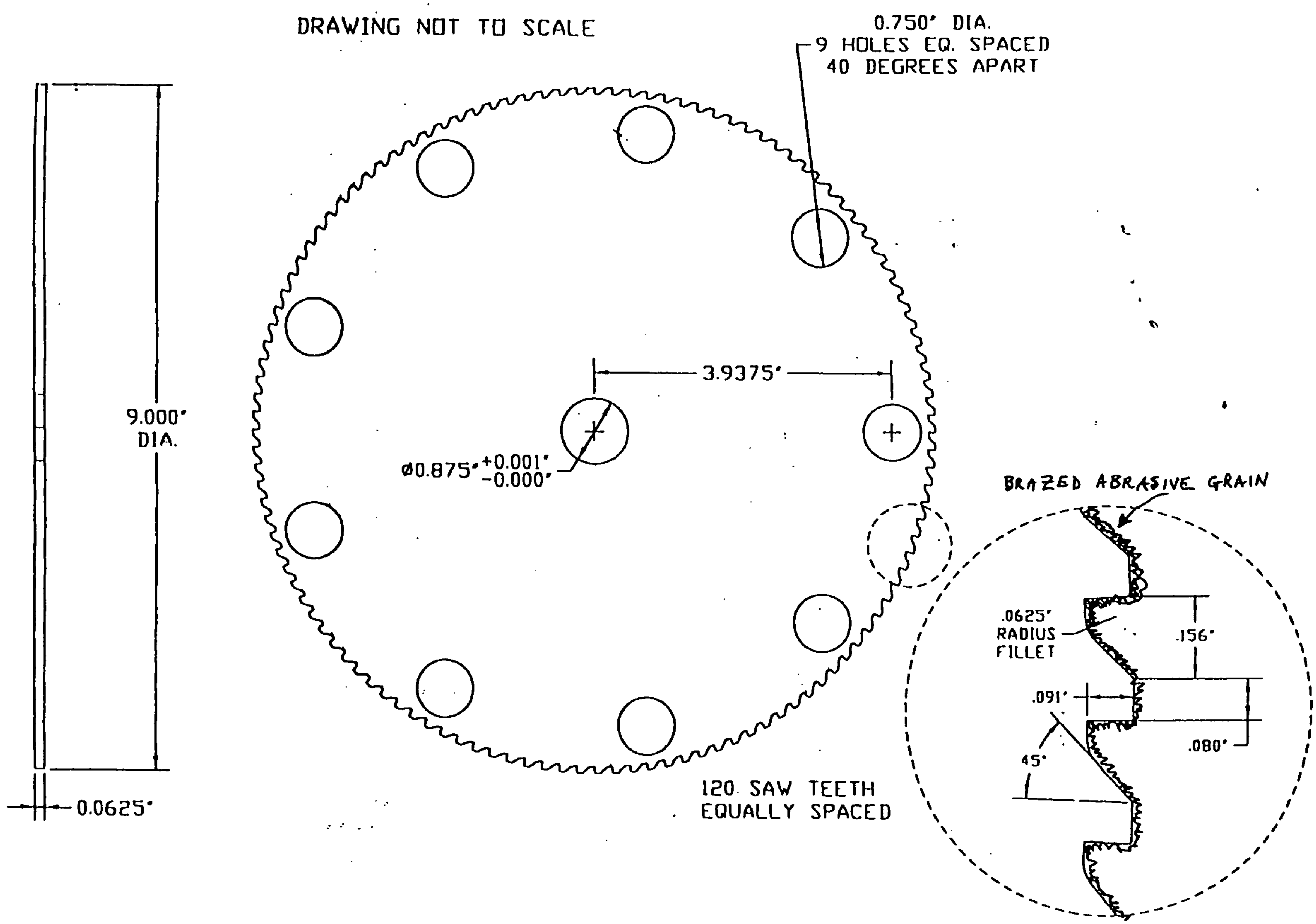


NOTES: MATERIAL: 86SS
TOLERANCES: +/- .005"
UNLESS OTHERWISE NOTED

CONFIDENTIAL

NORTON COMPANY

DWG.# 278

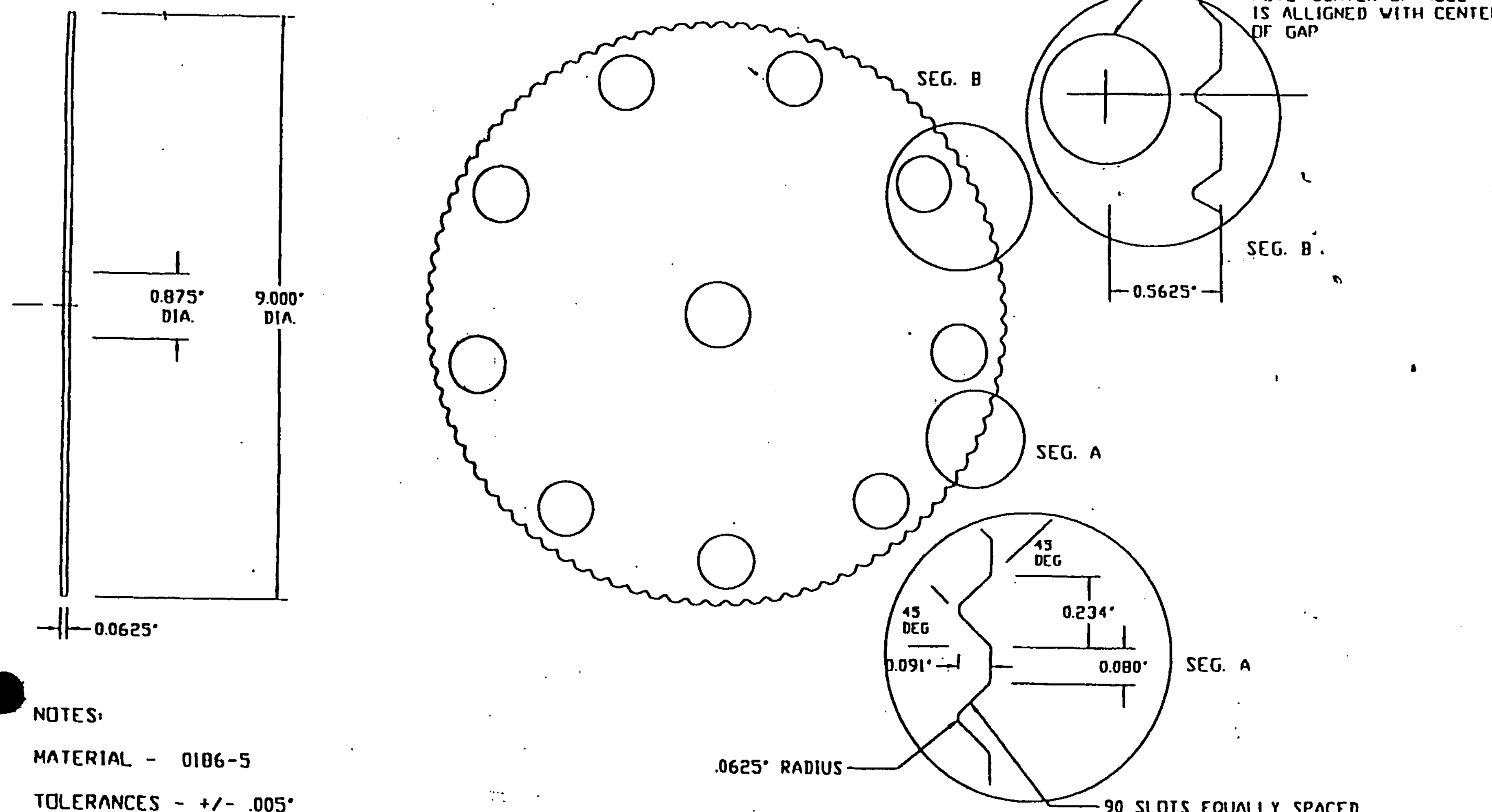


NOTES: MATERIAL: B6SS
TOLERANCES: +/- .005"
UNLESS OTHERWISE NOTED

CONFIDENTIAL

NORTON COMPANY	
DWG.# 277	

DRAWING NOT TO SCALE!



NOTES:

MATERIAL - 0186-5

TOLERANCES - +/- .005"
UNLESS OTHERWISE NOTED

NORTON COMPANY
CONFIDENTIAL
DWG.# E-plate